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**BUILDING A JOINT-SERVICE CLASSIFICATION RESEARCH  
ROADMAP: JOB ANALYSIS METHODOLOGIES**

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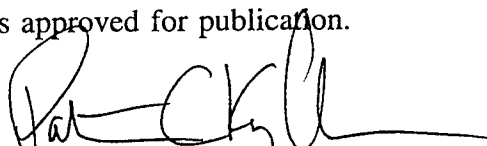
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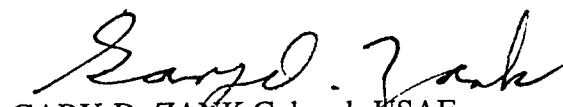
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## **PREFACE**

This technical paper documents research and development performed by the Human Resources Research Organization (HumRRO) for the Armstrong Laboratory, Human Resources Directorate, under Contract No. F33615-91-C-0015, JON 7719 2403. It is one of a series of six reports delivered under this contract.

The Roadmap project products describe across-service military classification research issues. The key to the success of this effort was the participation of experts from the Services. We thank the Service research and policy representatives who helped produce the original selection and classification objectives that provided the direction for this review. Additionally, we thank the operational personnel who provided information about, and insight into, each of the Services' occupational analysis programs. These personnel included representatives from the Air Force Occupational Measurement Squadron, the Army Personnel Command, and the Navy Occupational Development and Analysis Center. The individuals we interviewed were generous with their time, interest, insight, and information.

## SUMMARY

The Armstrong Laboratory, the Army Research Institute for the Behavioral and Social Sciences, the Navy Personnel Research and Development Center, and the Center for Naval Analyses are committed to enhancing the overall efficiency of the Services' selection and classification research. This means reducing redundancy of research across Services and improving inter-Service research planning, while ensuring that each Service's priority needs are served. With these goals in mind, the Armstrong Laboratory and the Army Research Institute co-sponsored a project to develop a Joint-Service classification research agenda, or Roadmap. The Roadmap Project has six tasks. This report documents the third task, a review and discussion of job analysis methodologies as they relate to joint Service selection and classification goals.

Our review is structured around a framework which provides for two major categories of job descriptive information: situation-oriented and person-oriented. Both types of information may serve as the foundation for the development of predictor and/or criterion measures, and are a means of clustering jobs for classification purposes. Situation-oriented information describes the nature of the work and/or the environment in which work is conducted. Person-oriented information describes the individual characteristics of people who are able to successfully perform various types of work in different contexts.

Within this framework, job analysis efforts may differ with regard to several factors, not the least of which is the level of specificity of the job description. In this report, we outline the types of situation-oriented and person-oriented job descriptive information that can be collected, then describe projects which have attempted to establish linkages between these two broad domains of description. Finally, we discuss this work in light of the selection and classification goals of the Services. Our major conclusions can be summarized as follows:

- There exists significant potential for improved scientific advancement and operational efficiencies with increased coordination of job analysis goals and activities both within and across Service lines.
- The question of the "right" job clustering taxonomy to use for personnel classification purposes is still an open one, and should be treated as such for purposes of future research.
- Analysis of National Guard and Reserve Forces is a problematic, but important goal for classification researchers.
- Job analysis technologies that have been minimally used by the Services in the past (e.g., critical incident analysis, cognitive task analysis) have the potential to support specific classification needs, such as criterion and predictor development.
- The selection and classification goals outlined in the first Roadmap project report should be expanded to include several additional job analysis-related objectives.

# **BUILDING A JOINT-SERVICE CLASSIFICATION RESEARCH ROADMAP: JOB ANALYSIS METHODOLOGIES**

## **I. Introduction**

The Air Force Armstrong Laboratory, the Army Research Institute for the Behavioral and Social Sciences, the Navy Personnel Research and Development Center, and the Center for Naval Analyses are committed to enhancing the overall efficiency of the Services' selection and classification research agenda. This means reducing redundancy of research efforts across Services and improving inter-Service research planning, while ensuring that each Service's priority needs are served. With these goals in mind, the Armstrong Laboratory and the Army Research Institute contracted with the Human Resources Research Organization (HumRRO) to develop a Joint-Service selection and classification research Roadmap.

The Roadmap project had six tasks. The first task, Identify Classification Research Objectives, involved interviews with selection and classification experts and decision-makers from each Service to determine research objectives. Tasks 2 through 5 consist of reviews of specific predictor, job analytic, criterion, and methodological needs of each of the Services. The final task, Prepare a Research Roadmap, integrates the findings of Tasks 1 through 5 into a master research plan.

This report documents the findings of Task 3. The goal of Task 3 was to review and discuss job analysis methods as they relate to the selection and classification research objectives outlined in Task 1 of the Roadmap project (Russell, Knapp, & Campbell, 1992). The objectives most directly related to job analysis methodologies are as follows:

- Investigate job clustering methods to improve potential for classification among appropriate job clusters rather than among individual jobs.
- Investigate job analysis methods that more adequately capture nonobservable job requirements for high level performance (e.g., cognitive task analysis).
- Design and evaluate job analysis methods that yield task to KSA linkages, within defined task and KSA taxonomies, so that worker attribute requirements for jobs are readily and systematically defined.
- Design and evaluate job analysis methods that identify the major contributions of individual performance to unit performance.
- Improve classification efficiency by improving strategies to generalize classification research findings across jobs and military populations.

Job analysis methodologies are more tangentially, although still importantly, related to other selection and classification objectives as well. For example, "Develop/evaluate alternative paradigms for the selection and classification decision sequence (e.g., manipulate timing of



classification decisions; make multi-level or multi-tiered classification decisions)" is an objective that could be accomplished more effectively with the development of improved job clustering strategies.

Our goal in this report was not to satisfy the selection and classification objectives outlined in Task 1. Indeed, we close the report with a revised set of objectives which clarify and broaden those listed above. Our revisions grew out of a review of the research and operational issues which comprise the main body of this report. This review includes a description of operational job analysis procedures and research efforts which are addressing (or could address) one or more aspects of these objectives.

### Scope of Review

McCormick (1976) outlined four elements which characterize a given job analysis approach: (1) the type of information used to describe the job, (2) the form of the information (i.e., qualitative or quantitative), (3) the method of gathering the information (e.g., observation, interviews), and (4) the agent from which information is gathered (e.g., supervisors, incumbents). Although we may touch on each of these characteristics in our review, our primary focus is on the first - the type of information used to describe the job. We choose this emphasis because the type of information collected in a job analysis program is intrinsically tied to the purposes that the analysis program does (or could) serve (e.g., Cornelius, Carron, & Collins, 1979; Pearlman, 1980). It is also arguably the most important conceptual distinction between various job analysis strategies because it reflects the nature of the outcome rather than the process.

The goals of a particular job analysis effort might be to support recruiting activities, selection and classification procedures, training programs, performance appraisal systems, wage and salary administration, and/or other organizational goals. Since different types of job analysis information are needed to support different organizational goals, multiple job analysis approaches may be necessary for an organization to adequately satisfy its needs. Nonetheless, it is possible that these different approaches could be used to support one another in some useful fashion. For this reason, we will not restrict the job analysis discussion to methodologies which solely support selection and classification systems (e.g., validity generalization, synthetic validity, standard setting). The Services have sophisticated job analysis systems which are primarily intended to support training programs and force structure decisions for general personnel management purposes (e.g., training, career progression). Our discussion of these systems will not address their utility for the support of training programs; we take it as a given that such analysis programs are necessary for this function. We will, however, comment upon their contribution (current or potential) toward addressing selection and classification goals.

### Framework for Review

Given the nature of the selection and classification objectives listed previously, and the correspondingly broad goals of this report, we will frame our discussion around taxonomies of

situation (i.e., work and environment) and person characteristics. All job analysis efforts, regardless of their scope and underlying goals, attempt to specify job demands and/or the individual (i.e., person) characteristics required for successful job performance. Furthermore, the elucidation of a general model which links situation-related needs with individual attribute requirements is a much sought after advancement in the science of personnel selection and classification (e.g., Guion, 1976; Peterson & Bownas, 1982). It is our view that, by matching individual job analysis efforts to this model, we will be in a better position to identify complementary and redundant research efforts, potential pitfalls in implementing the results of additional research, and strategies for more efficiently meeting different job analysis objectives.

Figure 1 depicts graphically our framework for discussing job analysis in this report. The figure shows a matrix of situation-related elements crossed by person-related elements. Cell entries reflect the degree of association between pairs of situation and person characteristics. That is, they reflect the extent to which each of the individual attributes are (1) required to perform each of the groups of tasks or behaviors and/or (2) required to work effectively under specific types of environmental conditions. The degree of association might be estimated in a number of ways, including validities based on empirical data or expert judgments on a Likert-type scale. Essentially, these would be estimates of the true correlation between individual differences in each person characteristic and individual differences in the ability to meet each job demand (i.e., performance).

Situation-Oriented Descriptors	Person-Oriented Descriptors						
	P1	P2	P3	P4	P5	P6...	Pk
S1	.0	.1	.3	.2	.	.	.
S2	.2	.1	.0	.3	.	.	.
S3	.3	.3	.2	.2	.	.	.
S4	.	.	.	.	.	.	.
S5	.	.	.	.	.	.	.
.							
.							
Sn	.	.	.	.	.	.	.

Note that the cell entries are true score correlations that reflect the strength of relationship between the two respective taxonomic elements.

**Figure 1.** Job Analysis Model

To elaborate a bit further, the elements which comprise the situation-oriented descriptors (i.e., S1, S2, S3...) may include characteristics such as task content requirements, worker behavior requirements, physical working conditions, and management practices to define job demands. The elements which comprise the person-oriented descriptors (i.e., P1, P2, P3...) may include knowledges; cognitive, psychomotor, and physical abilities or skills; vocational interests; personality characteristics; and so forth.

Figure 1 often reduces to a job-specific task by knowledge, skill, and ability (KSA) matrix when a single job is being studied. For increasing numbers of jobs, the elements (S1, S2, S3...; P1, P2, P3...) must necessarily become more general or else the model becomes too unwieldy to be useful. The situation and person elements will also take on a different look depending upon the scope of the investigation. For example, the person side may be restricted to cognitive abilities only or to abilities measured by a certain battery of tests (e.g., ASVAB, GATB). Similarly, the scope of the situation side might be limited to technical, nonsupervisory job requirements or to job content, rather than content and context, factors.

It might be useful at this point to contrast the job analysis model we are using with those posed by other theorists. Perhaps the most significant difference is the way in which contextual/environmental factors are treated. In our model, we combine these factors with the more narrowly focused work requirements (i.e., tasks and behaviors) which typically serve as criteria in validation research. For example, Peterson and Bownas (1982) discuss a job requirements matrix in which job tasks (i.e., criteria) are crossed by human abilities and characteristics. Although the authors restrict their review to these two areas, they point out that a taxonomy of task environments would also be needed to yield a complete information system for human resources allocation. Similarly, Schneider (1978) viewed contextual factors such as job characteristics and climate as moderators of the relationship between ability and performance.

Our model is not inconsistent with these views. Rather, we have chosen to combine job content and context factors to yield a complete, integrated description of the situation to which individual attributes can be matched. This reflects our view that conditions which maximize performance might be different for different types of people. In other words, if all people do their best work under the same conditions (e.g., in an autonomous work environment), then we need not consider the specific requirements imposed by these conditions when matching individual attributes with various types of work. Rather, positive conditions would only serve to enhance average performance across all individuals. However, if conditions will not be the same for all people or if some individuals respond differently to the same conditions, then we need to define work requirements in a manner that integrates content and context information to understand more fully the linkage between individual attributes and job demands.

The framework depicted in Figure 1 will allow us to discuss operational job analysis systems and related research efforts from a common perspective. In the next chapter, job analysis efforts using situation-oriented job descriptors will be presented. Chapter 3 will be devoted to person-oriented job descriptors. In Chapter 4, we will describe several efforts to

link the two types of taxonomies. With respect to the information offered in Chapters 2, 3, and 4, the reader should be advised that an exhaustive list of job analysis/taxonomic efforts will not be provided. Excellent reviews of this nature have been published by other authors (e.g., Cornelius, Carron, & Collins, 1979; Fleishman & Quaintance, 1984; Pearlman, 1980). Rather we will cover primarily recent efforts and those that appear to be of particular relevance to the military. Finally, in Chapter 5 we will present a summary and commentary of job analysis issues. This commentary will tie the issues back to the selection and classification objectives outlined at the beginning of the report.

### Issues to Consider During Review

A job analysis strategy may be ideal for one application (e.g., training), but less than ideal for another (e.g., job clustering for personnel classification). Therefore, the desirability of each of the job analysis taxonomies and methodologies described in the remainder of this report must be evaluated in light of one's job analysis goals. This rather simple piece of guidance is complicated by the fact that the Services' job analysis goals are diverse. Each Service has selection and classification systems to support, as well as training, performance management, and other needs which can or should be supported with job analysis activities. The ultimate Service-wide goal, then, is to adopt job analysis strategies that satisfy as many goals as possible, both within and across Service needs. In view of this "meta-goal," then, we encourage readers to consider not only the needs of their particular area of interest (e.g., Air Force or Navy classification), but of related needs as well (e.g., training needs of each Service). Before beginning our review, however, we will highlight briefly some of the job analysis capabilities that are apt to be of most interest to selection and classification researchers.

Desirable features for a job analysis system supporting selection and classification research can be extrapolated from the research objectives outlined at the beginning of the chapter. In particular, the system should (1) cluster jobs to maximize classification efficiency, and (2) provide situation-by-person linkages that will support the generalization of research findings to the population of military jobs. Job clustering capability requires that the descriptive taxonomy used be applicable across a large set of jobs. Thus, this feature is a must for job analysis intended to support selection and classification needs.

Job analysis strategies which allow researchers to distinguish job requirements which are common across jobs from job requirements that are more job-specific are also desirable. Individual attributes associated with common job requirements could be incorporated into the selection system and attributes associated with more unique job requirements would be candidates for the classification system.

Selection and classification activities will often entail predictor and criterion measurement development efforts. The need to gather information to support these efforts may dictate some features of the job analysis strategy (e.g., types of task ratings collected). From a larger perspective, however, an organization's philosophy regarding the use of predictors and the meaning of "job performance" is likely to determine the comprehensiveness

of its job analysis strategy. Specifically, one might begin by asking "What are the bounds regarding the measurement of individual attributes and performance in my organization?" For example, is the organization willing to consider all types of attributes as potential predictors or are some types (e.g., personality constructs) going to be off limits? Does the organization view the ability to perform critical job tasks as the only important aspect of performance or does it wish to consider both "can-do" and "will-do" aspects of performance when constructing/revising its selection and classification system? If the answer is narrowly focused (e.g., performance equals the ability to perform technical tasks), a job analysis strategy which is also narrowly focused is most likely to be selected. This decision, however, will then (1) constrain the nature of the selection and classification system that results from the research and (2) greatly reduce the feasibility of conducting collaborative research efforts across organizations. Our view is that job analysis strategies which are comprehensive in spite of organizationally-imposed boundaries will be more useful in the long run because they will serve cross-organizational needs, and they will also more easily adapt to changes in organizational philosophy that may occur in the future.

Related to the issue of predictor and criterion boundaries is the more general issue of system flexibility. Narrowly-scoped job analysis strategies may be more difficult to adapt to changes in the system. For example, the military force structure appears to be evolving into a smaller constellation of jobs, each of which involves a larger number of tasks than their predecessors. Ilgen (1992) has argued persuasively that job analysis systems must be structured to address such job changes. For example, the job clustering system(s) used by the Services needs to accommodate job evolution, and the resulting job clusters need to retain the positive features that led to the selection of the clustering strategy in the first place.

If the selection and classification system requires that minimum standards be set, then the job analysis strategy should incorporate some mechanism for supporting this need. For example, a minimum performance standard for each job task could be written by subject matter experts during the task analysis process. This information could then be incorporated into validation research that establishes minimum standards on the predictors. Alternatively, other strategies might be used to estimate minimum standards on the predictors directly. Similarly, job analysis strategies which incorporate the collection of information related to performance utilities could be invaluable in the design of selection and classification algorithms.

As the foregoing discussion indicates, there are several considerations regarding job analysis strategies which are particularly relevant to selection and classification needs. Other factors, such as the reliability and validity of job analysis data, the effectiveness and efficiency of data collection methods, and the cost of collecting job analysis data are concerns common to all job analysis efforts, regardless of the underlying goals of those efforts.

## II: Situation-Oriented Taxonomies

In this chapter we review job analysis strategies which describe jobs with respect to job content and context factors. Table 1 presents a summary of the job analysis activities to be discussed within the following framework (adapted from McCormick, 1976; Pearlman, 1980; Wheaton, 1973):

- Job-oriented descriptors
- Worker-oriented descriptors
- Environmental descriptors (e.g., job or organizational characteristics)
- Overall nature descriptions (e.g., job titles, brief job descriptions)

This framework can be interpreted as providing a continuum of specificity in which job-oriented analyses provide the most specific information and overall-nature work descriptions provide the most general information (cf., Harvey, 1991). The level of specificity that a job analysis must provide is closely tied to the purpose that the analysis is intended to serve. Very specific information is needed, for example, to support the development and refinement of training programs. More global information is needed to support the development of job classification structures since the same descriptors have to apply to many different types of jobs.

Table 1	
Situation-Oriented Job Analysis Efforts	
Job-Oriented	Worker-Oriented
Operational TI-CODAP systems Army Leader Requirements Survey	Position Analysis Questionnaire (PAQ) Job Element Inventory (JEI) Occupational Analysis Inventory (OAI) General Work Inventory (GWI) OPM Generalized Work Behaviors
Environmental	Overall Nature
Structure & Process Organizational Taxonomy	Project A MOS sampling procedure Navy Job Activities Inventory USES occupational descriptors

Job-oriented approaches are specific to a given job, or very homogeneous sets of jobs, and typically involve the delineation of detailed tasks that are performed by job incumbents. Worker-oriented approaches attempt to characterize jobs using descriptors which are not technologically-based or job-specific. This usually involves delineating general behaviors

(e.g., manipulate fine tools) which underlie performance of specific job tasks (e.g., repair a watch, repair a television picture tube). What we term "environmental" approaches characterize the work situation on the basis of contextual factors such as level of autonomy or availability of resources. Finally, "overall nature" represents an amalgamation of situation and person characteristics. Describing jobs simply by reference to job titles or brief job descriptions characterize this approach. We will discuss this strategy in the context of situation-oriented (as opposed to person-oriented) job analysis approaches under the assumption that job content is likely to be the primary consideration in this type of description.

### Job-Oriented Descriptions

The Air Force, Army, and Navy each have sophisticated programs designed to systematically obtain and analyze job-oriented data for enlisted personnel and commissioned officer jobs. Although there are some differences in the ways that each Service conducts its operational job analysis activities, all three use the Task Inventory/Comprehensive Occupational Data Analysis Programs (TI-CODAP) approach. CODAP refers to a collection of computer programs designed to analyze task inventory data in a variety of ways.

The TI-CODAP approach to job analysis was developed by the Air Force during the late 1950's and early 1960's. In addition to being used by the U.S. Armed Services (including the Coast Guard), the TI-CODAP methodology is used by some allied armed services (e.g., Australian Forces), civilian government agencies, academic institutions, and private organizations (CODAP, undated).

CODAP has evolved over the years from an ever-increasing collection of separate data analysis programs to two consolidated program packages which are periodically refined, expanded, and updated (CODAP, undated). ASCII CODAP was developed to run on a Unisys computer system. It includes a number of experimental programs that are used by the Air Force Human Resources Directorate for research and development purposes. Operational users, including the U.S. Air Force Occupational Measurement Squadron, generally use CODAP II which is written for IBM systems. CODAP II does not contain experimental programs, although users have the flexibility to adapt programs to their specific needs. CODAP software systems continue to evolve to fit a wide variety of hardware systems and user needs.

Christal and Weissmuller (1988) categorize CODAP programs into the following general categories:

- Data input and formatting
- Describing work performed by individuals or groups
- Comparing work performed by specified groups
- Empirically identifying jobs in an occupational area
- Analyzing task characteristics
- Performing special computations and displays

Of course, these categories are not mutually exclusive in that many programs combine one or more of these functions into one package.

Task inventories provide the raw data that feed into the CODAP system. Inventories are constructed with the assistance of subject matter experts (SMEs) for the job or jobs of interest, and typically consist of two sections (Christal & Weissmuller, 1988). The background section comprises questions which allow data analysts to group inventory respondents based on characteristics of interest (e.g., rank, command, location, sex). The task inventory section presents a comprehensive list of the tasks associated with the target job(s). At a minimum, job incumbents are asked to indicate the amount of time they spend on each task that they perform. Whenever feasible, all job incumbents are asked to complete the inventory. If the population of incumbents is large, however, a stratified random sample is used. Task inventories may also be completed by supervisors and trainers to get ratings on such variables as task difficulty and training emphasis requirements.

In the following sections we describe briefly the TI-CODAP systems operated by each of the Services. These descriptions will provide information about the characteristics of the data that are collected, who the data are collected from, and how the data are used. With regard to the characteristics of the data that are collected, we focus on (a) the way in which task statements are generated, (b) the level of task statement specificity, (c) the comprehensiveness of job content coverage (both within and across jobs), and (d) the types of scales used to rate the task statements. These characteristics determine the potential utility of the job analysis results for various purposes. For example, very detailed task statements are required for the development of programs of instruction. With regard to rating scales, data might be collected to estimate (a) the time spent on task performance, (b) importance of successful task performance, (c) the extent to which task performance contributes to successful overall job performance, (d) the extent to which tasks should be emphasized in formal training programs, and so forth. The importance of rating scale metric was emphasized by Harvey (1991) who used this characteristic as a primary component of his job analysis methodology taxonomy. His taxonomy characterized job analyses with respect to whether they incorporate (a) metrics which allow across-job comparisons (e.g., absolute frequency of performance), (b) metrics which do not allow comparisons across jobs (e.g., relative frequency of performance), or (c) no quantitative information at all.

In addition to the type of data that is collected in each of the Service's programs, we will describe who provides the data (e.g., incumbents, supervisors) and how the data are used (e.g., training, job classification, selection and classification).

Air Force procedures. The Air Force TI-CODAP operation is run by the U.S. Air Force Occupational Measurement Squadron. This operation is quite comprehensive in terms of the percentage of Air Force jobs which have been studied (J. Tartell, personal communication, June 5, 1992). All active duty jobs except for an isolated few have been surveyed at least once. Over the past eight years or so, surveys were conducted at the request of functional managers. In 1991, however, the Air Force started following a more fixed



schedule in which each Air Force Specialty (AFS) is to be surveyed approximately every five years.

Air Force task inventory lists are designed to cover all aspects of the job, including technical, leadership, professional education, and training responsibilities. The task statements are worded in AFS-specific language even if they refer to relatively general types of responsibilities (e.g., leadership). Inventory development begins with the assistance of SMEs at the appropriate AFS technical training school and includes several trips to field sites for additional SME input. Inventories completed by job incumbents include a performed/not performed scale and a nine-point relative time spent scale. Inventories completed by supervisors and trainers include a training emphasis scale and a learning difficulty scale. The learning difficulty scale is used to help set minimum aptitude standards and to provide additional information for the person-job-match system (Gould, Ruck, Driskill, & Tartell, 1988). Because of the diversity of positions within most AFS, the Air Force surveys the entire population whenever possible. Their rule of thumb is to cover the whole population if the number of incumbents is less than 3,000.

TI-CODAP results are provided to and used by the AFS training programs in a fairly systematic fashion (J. Tartell, personal communication, June 5, 1992). Use of the information for force structure modifications is somewhat less systematic. Enlisted force structure modifications are usually initiated through AFS Utilization and Training Workshops (U&TW) conducted by the Air Training Command (W. Archer, personal communication, March 11, 1992). The purpose of the U&TW is to update the Specialty Training Standard (STS), and review the AFS description, structure, and entry level requirements. During their deliberations, the U&TW participants have access to the latest TI-CODAP results for their AFS. In addition to the U&TW panels, there are several ad hoc ways of initiating changes to the force structure.

The Military Personnel Center is responsible for implementing AFS classification changes. Changes are staffed and coordinated across AFS and at all command levels prior to implementation. AFSs are themselves grouped into approximately 45 career fields. These groupings are based on expert judgments regarding similarity of job content.

The Air Force incorporates job analysis survey data into the Occupational Research Data Bank (ORDB; Longmire & Short, 1989). The ORDB allows on-line retrieval of a variety of occupational data relevant to manpower, personnel, training, and safety concerns. It has four basic components: (1) CODAP reports, (2) reference lists of occupational studies, technical reports and other relevant documents, (3) summaries of aptitude requirements, and (4) summaries of data on 125 variables drawn from other data files (e.g., Pipeline Management System, Uniform Airman Record). Although the ORDB was primarily intended to support research, the information is used operationally to help determine force structure changes and other needs associated with the introduction of new weapons systems.

Army procedures. The Army TI-CODAP operation (known as the Army Occupational Survey Program - AOSP) is run by the Army Personnel Command (PERSCOM). Previously,

the program had been conducted by the Training and Doctrine Command (TRADOC) but was shifted to PERSCOM to broaden the perspective of the effort. Although a large number of military occupational specialties (MOS) have been surveyed at one time or another, up-to-date survey data are retrievable for only a subset (perhaps one-half) of currently existing MOS (R. Stump, personal communication, July 6, 1992). In the past, surveys were conducted at the request of training proponents. In responding to these requests, the AOSP planners considered factors such as time since last survey, size of population, introduction of new equipment or doctrinal procedures, and interest in MOS restructuring. In the future, PERSCOM plans to institute a more systematic strategy for selecting MOS for study that will ensure wider MOS coverage. The Army is also investigating more efficient survey procedures to reduce the time required to collect job analysis information.

Normally, Army task inventory lists are designed to cover MOS-specific, technical tasks only (R. Stump, personal communication, June 4, 1992). Job incumbents rate tasks on a seven-point absolute frequency scale (Goldman & Worstine, 1986). In most cases, Army inventories completed by incumbents also include a section for rating the importance of "skills, knowledge, and abilities." This section lists job requirements which are not covered by information provided in the task lists. The statements are a mix of "traditional" knowledge (e.g., knowledge of anatomy/physiology), attribute-oriented (e.g., hand/eye coordination), and worker-oriented (e.g., use hand/power tools) elements. With respect to supervisor surveys, tasks are rated on a seven-point training emphasis scale.

Because Army inventories focus on MOS-specific technical skills, inventory development begins with the Soldier's Manual (SM) for the relevant MOS. The SM is written by the MOS proponent and provides a comprehensive list of MOS-specific tasks and associated doctrinal procedures. The proponent identifies critical tasks which must appear on the inventory. The inventory list is refined with SME input (training and field). As a general rule, surveys are distributed to all enlisted job incumbents provided the population size is less than 1,000. Otherwise, a stratified random sample is selected.

In 1992, the Army suspended its routine AOSP procedures to support the Operation Desert Shield/Storm (ODS/S) survey program. The purpose of the ODS/S AOSP program has been to capture lessons learned about task performance in a wartime environment. That is, what do soldiers really do in a wartime environment compared to what the proponents think that they would or should do? A total of 75 officer and enlisted MOS which played a significant role in ODS/S were selected for analysis in this special effort. Some common soldiering tasks have been included on the ODS/S surveys because of the unique goals associated with this research effort. Further, job incumbents (i.e., those in the MOS who participated in ODS/S) rate the importance of each task for accomplishing the unit mission during ODS/S on a five-point scale. The absolute frequency scale is not being used because of the lapse of time between ODS/S and survey administration. The same training emphasis scale is being used for both routine and ODS/S surveys.

As with the Air Force, the primary purpose of the AOSP is to support training and job classification for force management purposes. In part because large numbers of MOS have

not yet been surveyed, the link between AOSP data and these management functions is not systematic across the force. Job classification changes are usually requested by MOS proponents who may or may not base their reasoning on AOSP data. PERSCOM is responsible for collecting the relevant information regarding a requested change in force structure and staffing the decision process. Thus, on the surface at least, the force structuring process and the extent to which it is based on job analysis data is not fundamentally different between the Army and Air Force. The Air Force, however, uses its job analysis data more systematically than the Army for training applications.

Although the AOSP procedures do not incorporate information about non-technical task requirements, the U.S. Army Research Institute conducted an Army leader requirements task analysis to support the Center for Army Leadership and the U.S. Army Sergeants Major Academy in designing leadership development programs (Steinberg & Leaman, 1987; Steinberg, van Rijn, & Hunter, 1986). The Leader Requirements Survey (LRS) was designed to be consistent with the AOSP inventory format, and was administered Army-wide to officers and NCOs in 1987. The LRS includes 560 tasks listed under 20 duty areas.

Navy procedures. The Navy Occupational Development and Analysis Center (NODAC) is responsible for carrying out the Navy's occupational analysis program. This program addresses job classification requirements for modifications to the force structure. Unlike the Air Force and Army, training requirements are met with other survey efforts conducted independently by the various training proponents. Therefore, training interests are not a key consideration in the design of NODAC's occupational analysis program.

All of the approximately 79 ratings (i.e., job types) in the Navy have been surveyed at least once (J. Smith, personal communication, June 12, 1992). At this point, the schedule calls for ratings to be surveyed approximately once every four years.

Task statements are written at a more general level than those found on the Air Force and Army inventories. Whenever possible, tasks are written so that they are not equipment-specific. A subset of 141 tasks is general enough to be included on every inventory, regardless of rating. These tasks include activities such as writing letters and performing general maintenance functions. Task coverage includes technical, non-technical, and leadership job components.

Incumbents rate tasks using two scales. The first is a relative time spent scale. The second is a level of involvement scale which is used to help establish performance standards. Currently, the level of involvement scale has three points: (1) supervise, (2) do, (3) don't do. The Navy is studying variations on this scale, including the following five point alternative: (1) supervise, (2) do and supervise, (3) do, (4) learn and help, and (5) don't do. The Navy does not administer its task inventories to supervisors.

Marine procedures. The Marine Corps does not have its own occupational analysis program. Instead, it makes use of relevant data collected by the other Services on similar jobs.

Commentary. The Services use TI-CODAP data primarily to support training programs and force structure modifications (i.e., aggregating or disaggregating jobs). Since selection and classification efforts (both research and operational) function relatively independently of training efforts, little attention has been given to making these routine job analysis operations more informative for selection and classification problems. As we will see in Chapter 3, some use has been made of the job analysis information which is collected to support selection and classification goals. These applications, however, still take the task information as a given with little consideration for changing the operational system for collecting the data.

The Air Force has a task analysis system which appears to have the potential to serve a wide variety of goals. For example, the comprehensive scope of the task lists makes them potentially useful for a wider range of problems than task lists that are more restrictive in coverage. The availability of the ORDB likely increases the extent to which task analysis information is used by a variety of people, including those in operations, research, or even outside the Air Force community. That is, the more accessible the information, the more likely people will think to use it. Another example is the task learning difficulty ratings which are collected from supervisors. This rating, when benchmarked across AFS, is used to help set enlistment standards (Gould et al., 1988). The other Services' occupational analysis systems do not provide information that is as directly relevant to standard setting exercises as these rating data. As a last example, the fact that the Air Force has been successful at maintaining a reasonably complete and up-to-date library of occupational analysis information makes this library more useful than it would be otherwise.

At least two characteristics of the Air Force occupational analysis system work to limit the utility of the results. The first is that task statements are written such that they apply exclusively to the AFS under study. In comparison, Navy task statements are much more general, and thus more suitable for job classification efforts. The second is that tasks are rated on a relative time spent scale which reduces the ability to compare this variable across jobs or even positions within jobs. Indeed, the Army is the only Service which uses an absolute scale for estimating time spent on task performance.

It is reasonable to suspect that the relatively broad orientation of the Air Force occupational analysis system is a result of the inclusion of many interested parties in the research and development process. Thus, while training interests may be the most significant in determining the final form of the analysis system, other interests are considered as well. In the Army, however, the analysis system is more exclusively devoted to the needs of training. This more focused orientation may or may not lead to data which are more useful for training purposes than those collected by the Air Force. That comparison is beyond our scope. Increased consideration of other organizational needs, however, is bound to increase the overall utility of the analysis program without necessarily sacrificing information needed for training. It is this reasoning that led the Army to move the AOSP from TRADOC to PERSCOM control.

A limitation of all of the Services' job analysis programs is that little information regarding the National Guard and Reserves has been collected. Although efforts are being made to address this deficiency, the logistical problems associated with surveying these part-time populations are significant. Nonetheless, it is becoming increasingly clear that part-time military personnel do their jobs, both during peacetime and wartime, differently than their active duty counterparts. Furthermore, the need to ensure that these populations are being selected, classified, and trained in an adequate manner is becoming more pronounced with growing public scrutiny following the recent hostilities in Southwest Asia.

The availability of a library of current task analysis information for most jobs in a Service is a very difficult goal to achieve. As mentioned previously, the Air Force and Navy appear to have been fairly successful in achieving this goal, in part because they have fewer jobs to survey in comparison to the Army. It takes roughly one to two years to complete a job analysis from start to finish. Furthermore, the number of jobs to be analyzed is immense; for example the Army has over 250 MOS it is trying to track. Clearly any strategies that could make this goal more attainable are worth considering. For example, computerized inventory development and administration might shave precious time from the analysis process (Hudspeth, Fayfich, & Price, 1990). Abbreviated analyses on smaller samples might be sufficient for jobs which have been analyzed previously and show limited outward changes. It is also conceivable that highly similar jobs across Services could be analyzed together to economize time and resources. This latter step would be difficult to manage in the short run because of the different strategies currently advocated by each Service; but the fundamental goals of the analysis programs in each Service are similar enough to make this idea workable in the long term.

### Worker-Oriented Descriptions

The archetypical worker-oriented approach to job analysis is the Position Analysis Questionnaire (PAQ; McCormick, Jeanneret, & Mecham, 1972; Mecham, McCormick, & Jeanneret, 1977). The PAQ was developed on the theory that a set of "building block" behaviors underlie the successful performance of all jobs, and could therefore be used to compare and contrast jobs with each other. PAQ job elements are organized into the following six areas:

- |                     |                                    |
|---------------------|------------------------------------|
| • Information input | • Relationships with other persons |
| • Mental processes  | • Job context                      |
| • Work output       | • Other job characteristics        |

Although the reliability of PAQ job analysis data is reasonably high (e.g., Cornelius, De Nisi, & Blencoe, 1984), variations of the original PAQ methodology have been developed to address some factors which have limited the original instrument's usefulness. For example, the instrument is written at a post-college reading level (Ash & Edgell, 1975). The Job Element Inventory (JEI; Cornelius & Hakel, 1978) was designed to have a lower reading grade level (estimated at 10th grade). The JEI was originally used for an analysis of Coast Guard jobs for performance appraisal development purposes.

The Occupation Analysis Inventory (OAI) was designed to support the development of tools for career exploration (Cunningham, Tuttle, Floyd, & Bates, 1974). It departs from the PAQ approach in that it attempts to retain a considerable amount of job content (i.e., job-oriented) information without losing its applicability to the full range of occupations. As a result it is much longer (617 work elements versus 187 for the PAQ). The five major elements covered by the OAI are as follows:

- Information received
- Mental activities
- Work behavior
- Work goals
- Work context

Over the past decade, the Air Force has developed and conducted research on a derivative of the OAI known as the General Work Inventory (GWI; Ballentine & Cunningham, 1981; Cunningham & Ballentine, 1982). The purpose of this R&D effort has been to provide an option for supplementing the task-based information routinely collected in the TI-CODAP program described previously. This less job-specific analysis approach was taken primarily to support advances in job classification methods. The GWI categorizes its 268 elements into the following categories:

- Sensory requirements
- Information elements
- Physical activities
- Interpersonal activities
- General mental requirements
- General physical requirements
- Work conditions
- Job benefits/opportunities

All elements, except those categorized under work conditions and job benefits/ opportunities, are rated on a nine-point part-of-job scale. Elements in the latter two categories are rated on a nine-point extent-of-occurrence scale.

Another example of a worker-oriented job analysis taxonomy was developed by the U.S. Office of Personnel Management (OPM) to cover over 100 Federal professional and administrative occupations (O'Leary, Rheinstein, & McCauley, 1989). The taxonomy was based on work conducted by Outerbridge (1981) who based her original taxonomy on duty statements for related occupations found in the Dictionary of Occupational Titles (DOT). Duty statements taken from OPM Classification and Qualification Standards for 113 Federal professional and administrative occupations were sorted into the 32 work behaviors developed by Outerbridge. Duty statements which were not covered by the 32 work behaviors were grouped among themselves. This resulted in the addition of 25 work behaviors to the original Outerbridge taxonomy. Relative-time-spent ratings were gathered on the 57 Generalized Work Behaviors from approximately 6,000 job incumbents. These data were used to cluster jobs into families. An example of a work behavior statement developed in the OPM research is shown below:

Presents information about work of the organization to others: e.g., Describes agency programs and services to individuals or groups in community or to higher management.

### Environmental Descriptions

A taxonomy of organizational characteristics known as the Structure and Process Organizational Taxonomy (SPOT) was recently developed by the Air Force (Appel, Grubb, Elder, Leamon, Watson, & Earles, 1991). The philosophy underlying development of this taxonomy was that job performance is a function of task-related skills (ability to perform job tasks) and organization-related skills (ability to adapt to the organization). Elements for SPOT were drawn from taxonomic work conducted by Indik (1968) and Sells (1968). SPOT comprises 14 dimensions and 50 sub-dimensions. The 14 dimensions are:

- Communication
- Coordination
- Managership
- Degree of Flux
- Role Specification
- Leadership
- Externally Imposed Change
- Control
- Socialization/Integration
- Relations w/ Social Environment
- Conflict Control Processes
- Degree of Bureaucracy
- Availability of Resources
- Natural Environmental Conditions

Using this taxonomy, a panel of four experts (two psychologists, one Air Force officer, and one Army officer) characterized the Air Force on the basis of the 50 sub-dimensions by rating each using a three-point scale. Using this organizational profile, the Air Force developed a biodata instrument for predicting leadership effectiveness called the "Leadership Effectiveness Assessment Profile" (LEAP; Appel, Grubb, Shermis, Watson, & Cole, 1990).

### Overall Nature Descriptions

An overall-nature-of-the-job-approach was used by researchers at the beginning of the Army's large scale selection and classification project (Project A). Their aim was to cluster Army enlisted jobs into groups based on job content, and then use these clusters to select a representative sample of 19 MOS to include in the research project (Rosse, Borman, Campbell, & Osborn, 1984). Army psychologists (n=17) and field-grade officers (n=8) sorted 111 entry level MOS into categories based on the following information for each MOS: (1) job title (without numerical descriptor), (2) one-sentence MOS description, and (3) paragraph summarizing task requirements. Interrater reliability estimates for the sorting judgments were high, and the resulting MOS classification scheme, comprising 23 job clusters, was used to sample MOS for inclusion in the Project A research.

The Navy is currently conducting a project to examine alternative ways of clustering Navy ratings in job families for selection and classification purposes (Reynolds & McCloy, 1991). This effort is not using a truly overall-nature-of-the-job approach. Rather, a single job analysis data collection instrument, the Job Activities Inventory, is being used to collect Navy-wide data on job-oriented, worker-oriented, and individual attribute requirements. Job-oriented items on the inventory come from the Navy Occupational Categories which provide a set of task descriptions relevant to a broad range of Navy ratings (e.g., Operate gas, steam, or hydraulic machinery). Worker-oriented items on the inventory were adapted from a short

form of the PAQ developed previously for the Navy (Harris & McCormick, 1973) and from the JEI. Attribute items were based primarily on the taxonomy described by Fleishman and his associates. The Job Activities Inventory has 61 worker-oriented items, 20 job-oriented items, and 27 ability items. Data are currently being collected on this instrument from a sample of senior NCOs across all entry level Navy ratings.

The Department of Defense (DoD) linkage project (Harris, McCloy, Dempsey, Roth, Sackett, Hedges, Smith, & Hogan, 1991) provides another example of an effort to combine different types of job descriptors to create a job descriptive system. They started with the United States Employment Service (USES) Dictionary of Occupational Titles (DOT) which provides job analysis information for the entire spectrum of jobs in the civilian labor force. Job analysis of this scope cannot capture detailed job tasks for each occupation, but less specific behavioral/task requirements and person-oriented requirements are assessed. Specifically, the DOT provides a brief narrative description of task and behavioral requirements as well as ratings on 44 variables which reflect (1) worker functions - the level of complexity with which workers work with data, people, and things, (2) time required for training, (3) aptitudes, temperament, and interests, (4) physical demands, and (5) environmental conditions.

The DOT was used because it represented a common base of information available for jobs across the different Services. Specifically, DoD had developed previously a crosswalk between civilian occupations listed in the DOT and military occupations (Lancaster, 1984). This crosswalk was used to identify the civilian counterparts to 965 entry level military occupations. To create a more parsimonious set of descriptors, the values for the 44 variables were subjected to principal components analysis to yield four components labeled (1) working with things, (2) cognitive complexity, (3) working conditions, and (4) fine motor control.



### **III: Person-Oriented Taxonomies**

There are two typical approaches used to identify individual attribute requirements of jobs in job analysis (Landy, 1988). In one approach, job analysts conduct a task analysis and then develop a list of attributes which, based on research literature and/or past experience, they consider likely to be required for successful performance of the identified job tasks. In the second approach, subject matter experts (SMEs) generate a list of attributes based on their knowledge of task performance requirements. In either case, the list of required individual attributes (usually in the form of "KSAO") is inferred on the basis of an understanding of job content. This inferential process has always been the "magical" part of job analysis that is considerably less straightforward than the process of defining the tasks or work behaviors which constitute the job.

Historically, the Services have been able to avoid the problem of making the inferential leap between tasks and individual attribute requirements. Indeed, the clustering of military jobs for selection and classification purposes has heretofore been based on individual attributes (i.e., cognitive ability as measured by the Armed Services Vocational Aptitude Battery-ASVAB) without regard to job analysis information per se. Rather, the clusters have been based primarily on the empirical relationship (i.e., validity estimates) between enlistment test scores (i.e., Armed Services Vocational Aptitude Battery - ASVAB) and training performance. These job clustering schema will be described later in this chapter.

Because the Services must select and classify individuals into such a large and diverse set of jobs, it makes sense to start with a taxonomy of all possible potential predictors. The age and inexperience of the military's applicant population, however, is such that the range of potential predictors must generally be limited to abilities and general knowledges rather than to job-specific knowledges and skills.

In recent years, the Services have become interested in using new selection and classification tests and basing the use of these tests on their relationship to job performance. One implication of this movement is that, unless empirical data linking scores on potential predictors to job performance are available for all jobs, strategies for inferring individual attribute requirements for each military job will have to be established. As we have mentioned previously, these strategies are likely to incorporate synthetic validity or validity generalization techniques. Application of these techniques will require the selection of a person-oriented taxonomy which depicts the range of possible individual attributes (i.e., predictors) which might be required for any given job. Another implication of this movement is that the ASVAB-based taxonomy must be expanded enough to at least incorporate additional cognitive classification tests (e.g., measures of spatial ability). Greater expansion to the list of possible predictors to include non-cognitive individual attributes (e.g., interests), however, will provide the Services with greater flexibility in their selection and classification research programs and systems.

The goal of this chapter is to describe briefly several different types of person-oriented taxonomies that could be considered for use in place of, or in conjunction with, the ASVAB-based taxonomies currently in use. The chapter is not intended to be a comprehensive literature review of predictor constructs, as such a review is provided in the Roadmap Task 1 report. Rather, our intent is to illustrate types of attribute job descriptors (e.g., personality constructs, physical abilities) and methods for identifying, defining, and using person-oriented job descriptive information.

### Cognitive Ability Descriptions

#### Traditional Cognitive Taxonomies

Traditional cognitive attribute taxonomic research relies on factor analysis of cognitive test scores, coupled with rational judgment, to delineate the organization of the taxonomy as well as the number of meaningful sub-abilities contained therein. One of the first broad-based cognitive abilities testing projects of this nature was Thurstone's (1938) primary mental abilities study. Thurstone administered 56 tests, designed to tap a wide range of abilities, to 218 subjects. He extracted 13 factors from the test score correlations, but could only label nine. These were:

- |                    |                |
|--------------------|----------------|
| • Perceptual Speed | • Number       |
| • Verbal Relations | • Word Fluency |
| • Memory           | • Induction    |
| • Reasoning        | • Deduction    |
| • Space            |                |

Reanalyses of Thurstone's data identified a general factor underlying performance on all of the tests in his battery (Eysenck, 1939; Spearman, 1939). Since that time, a number of specific cognitive abilities, and a general ability factor, have been identified in numerous factor analytic studies (e.g., Gustafsson, 1984).

Several major contributors to cognitive abilities research attempted to summarize factor-analytic abilities research through the mid-1970s (e.g., Ekstrom, French, & Harman, 1979). An example of a more recent effort is Horn (1989). Horn attempted to integrate new information processing constructs with traditional factor-analytic definitions and to organize factors in terms of their breadth. Narrow factors are ones for which the intercorrelations among sub-factors are large; broad factors are defined by tests that are not as highly intercorrelated. He defines seven broad cognitive attributes and two others that are relatively broad (see Figure 2).

*Knowledge or Crystallized Intelligence* ( $G_c$ ) underlies performance on knowledge or information tests. *Broad Reasoning or Fluid Intelligence* ( $G_f$ ) subsumes virtually all forms of reasoning-inductive, conjunctive, deductive, and so forth. According to Horn, tests (e.g., verbal analogies) are good reasoning measures to the extent that they contain words that are equally familiar, or unfamiliar, for all examinees. Otherwise variance due to word knowledge

makes such tests resemble measures of  $G_c$ . *Broad Visual Intelligence* ( $G_v$ ) is Horn's broad spatial attribute, including all spatial constructs where speededness is not important. *Short-Term Acquisition and Retrieval* (SAR) encompasses tasks that involve sequential processing of information in short term memory. Recency memory, for example, requires recalling the most recently presented stimuli, out of a string of stimuli presented, in temporal order. *Long-Term Storage and Retrieval* (TSR) constructs refer to the organization of information or concepts in long-term memory and the fluency of retrieval. *Broad Speediness* ( $G_s$ ) underlies performance on all types of speeded measures including clerical or perceptual speed and visual matching tasks. *Auditory Intelligence* ( $G_a$ ) "represents a facility for chunking streams of sounds, keeping these chunks in awareness, and anticipating an auditory form that can develop out of such streams" (p. 84). Horn contends that *Quantitative Thinking* ( $G_q$ ) should (and can) be distinguished from  $G_c$  and  $G_f$  because mathematics plays a significant role in educational guidance and placement decisions. Similarly, Horn proposes *English Adeptness* (ENG) because tests that measure it are useful for diagnosing language difficulties.

Cognitive Attributes		Related Constructs
$G_c$ -	Knowledge or Crystallized Intelligence	Knowledge of general information Word knowledge
$G_f$ -	Broad Reasoning or Fluid Intelligence	Inductive reasoning Conjunctive reasoning Deductive reasoning
$G_v$ -	Broad Visual Intelligence	Spatial visualization Spatial orientation
SAR -	Short Term Acquisition and Retrieval	Recency memory Word span
TSR -	Long Term Storage and Retrieval	Associational fluency Expressional fluency Ideational fluency
$G_s$ -	Broad Speediness	Visual scanning Visual matching
$G_a$ -	Auditory Intelligence	Discrimination among sound patterns Auditory cognition of relations
$G_q$ -	Quantitative Thinking	Computational fluency Numerical computation
ENG -	English Adeptness	Word parsing Phonetic decoding

**Figure 2.** Horn (1989) Cognitive Ability Taxonomy

### Processing-Based Cognitive Taxonomies

Representing a different approach to the establishment of a cognitive ability taxonomy is the Air Force's Learning Abilities Measurement Program (LAMP), a basic research program for the study of individual differences in cognition (Kyllonen, 1985, 1991). Over the course of the last six years, LAMP researchers have developed over 1,000 computerized tests, four versions of the "Cognitive Abilities Measurement" (CAM) battery, and a taxonomy of cognitive attributes. Unlike traditional cognitive attribute-based taxonomies that are rooted in factor analysis, the CAM taxonomy is derived from an information-processing framework. It includes seven kinds of processing variables as shown in Figure 3. The seven process factors are fully crossed with three major types of stimuli: verbal, quantitative, and spatial. LAMP researchers have designed tests for each cell of the CAM taxonomy. For example, there are three working-memory capacity tests, each of which uses a different type of test item (i.e., verbal, quantitative, or spatial).

Processing Variables	Types of Stimuli		
	Verbal	Quantitative	Spatial
Working-memory capacity			
Processing speed			
Declarative knowledge			
Procedural knowledge			
Declarative learning			
Procedural learning			
Temporal processing			

**Figure 3.** The Cognitive Abilities Measurement Taxonomy

The inter-relationships among the CAM components have not been fully explored. Initial results, however, suggest that there is a strong general factor underlying performance on the CAM tests and working-memory capacity measures load very highly on the first general factor (Kyllonen, 1992). Also, note that the CAM taxonomy is not inconsistent with the Horn (1989) taxonomy previously described. It simply explores the information processing aspect of cognitive functioning more fully.

The CAM constructs, having grown out of information processing research, have not been directly linked to job activities. Recognizing this, Kyllonen (1985) proposed an approach for linking the specific content of cognitive tests to the cognitive requirements of jobs:

Such an approach, in principle, would require (a) the determination of what cognitive skills are required in training and in the work place, (b) the determination of what cognitive skills are involved in taking psychological tests, and (c) the matching of training/job skills with cognitive task skills and thereby logically deriving training/job skills requirements (p. 7).

Newly evolving cognitive task analysis (CTA) procedures, designed to delineate experts' mental models of a problem, also may prove useful for linking the CAM constructs to work behaviors. CTA procedures generally involve interviewing individuals who are expert in a particular area to map out decision points in a pre-selected job task and to identify segments of a task that are difficult for novice performers, but not for the expert (e.g., Eggemeier, Fisk, Robbins, Lawless, & Spaeth, 1988; Glaser, Lesgold, & Gott, 1991). The primary result is a model of the cognitive processes involved in the accomplishment of the task and a description of differences between processing skills of experts and novices.

### The Services' Cognitive Taxonomies

As mentioned previously, the Services use ASVAB-based taxonomies to describe and cluster enlisted jobs. The ASVAB is a battery of ten cognitive subtests. These tests measure the cognitive abilities shown in Table 2. ASVAB composites are combinations of ASVAB subtests that predict training performance for a broad class of occupations. Said another way, the composites are the current attribute descriptors for military occupational groups. Abellera (1976) summarized the evolution of this type of job clustering:

- Eligibility for assignment to jobs involving, for instance, mechanical work, was determined by the score a person achieved on a test purportedly predictive of mechanical aptitude. Thus the qualification of individuals for assignments to all occupations in which mechanical work predominated was governed by the score attained on the mechanical aptitude test. Similarly, other occupations characterized by another common and essential type of work such as clerical activities, were grouped together in occupational "clusters" corresponding to the common aptitude required (p. C-3).

In this context, occupational clusters and cognitive attribute descriptors (composites) are inextricably bound to each other. Cognitive attribute requirements (or evidence of their validity) drives the clustering of jobs.

Each Service develops its own composites. Names of the current ASVAB composites and their constituent ASVAB subtests appear in Table 3. The Air Force uses four composites--Mechanical, Administrative, General, and Electronics--or MAGE. The Army uses nine; the Marine Corps uses four, and the Navy has 11. As shown in Table 3, the

Services have identical electronics composites. Other composites, even those with the same name, are defined by different subtests by different Services.

Table 2		
Description of ASVAB Subtests		
<u>ASVAB Subtest</u>	<u>Number of Items</u>	<u>Definition</u>
General Science (GS)	25	Knowledge of or about physical, chemical, and life properties.
Arithmetic Reasoning (AR)	30	Reasoning required to perform arithmetic processes.
Word Knowledge (WK)	35	The meaning of selected words.
Paragraph Comprehension (PC)	15	Understanding of written material from brief paragraphs.
Numerical Operations (NO)	50	Knowledge of simple addition, subtraction, multiplication, and division.
Coding Speed (CS)	84	Ability to identify and match sets of numbers with words.
Auto and Shop Information (AS)	25	Knowledge of and familiarity with tools and shop practices, maintenance, structure, and repair of automobiles.
Mathematical Knowledge (MK)	25	Application of learned mathematics principles.
Mechanical Comprehension (MC)	25	Understanding and application of various mechanical principles.
Electronics Information (EI)	20	Identification or application of simple electric or electronics knowledge.

Table 3				
Current ASVAB Composites Used for Assignment by Service				
Army	Air Force	Marine Corps	Navy	ASVAB Subtests
General Technical (GT)	General (G)	---	General Technical (GT)	AR + WK + PC
---	---	General Technical (GT)	---	AR + WK + PC + MC
Electronics (EL)	Electronics (E)	Electronics Repair (EL)	Electronics (EL)	GS + AR + MK + EI
Clerical (CL)	---	---	---	WK + PC + AR + MK
---	Administrative (A)	---	Clerical (CL)	NO + CS + WK + PC
---	---	Clerical (CL)	Business and Clerical (BC)	MK + CS + WK + PC
Motor Maintenance (MM)	---	---	---	NO + AS + MC + EI
---	---	---	Mechanical (ME)	AS + MC + WK + PC
---	---	Motor Maintenance (MM)	---	AR + AS + MC + EI
---	Mechanical (M)	---	---	GS + 2AS + MC
Combat (CO)	---	---	---	AR + CS + AS + MC
Field Artillery (FA)	---	---	---	AR + CS + MK + MC
Operators/Foods (OF)	---	---	---	NO + AS + MC + WK + PC
Surveillance/Communications (SC)	---	---	---	AR + AS + MC + WK + PC
---	---	---	Basic Electricity/ Electronics (E)	GS + AR + 2MK
Skilled Technical (ST)	---	---	---	GS + MK + MC + WK + PC
---	---	---	Boilerman/Enginemen/ Machinist Mate (EG)	AS + MK
General Maintenance (GM)	---	---	---	GS + AS + MK + EI
---	---	---	Machinery Repairman (MR)	AR + AS + MC
---	---	---	Submarine (ST)	AR + MC + WK + PC
---	---	---	Communications Technician (CT)	AR + NO + CS + WK + PC
---	---	---	Hospitalman (HM)	GS + MK + WK + PC

Source: Bloxom (1992).

The Air Force Cognitive Taxonomy. The four Air Force job clusters have been used in one form or another since the mid-1950s (Weeks, Mullins, & Vitola, 1975). They evolved through expert judgment coupled with empirical evidence about the relationships between ASVAB subtests and performance in Air Force training. MAGE has been shown to be "remarkably robust considering the myriad of changes that have taken place since the system was first established" (Alley, Treat, & Black, 1988, p. 10). Alley et al. computed regression equations for predicting performance in 211 training schools, and clustered the individual equations on the basis of their regression weights. After forming clusters, they computed composite regression equations for each cluster. Six clusters were defined, four of which were equivalent to the existing M, A, G, and E clusters in terms of job content and profiles of regression weights. The remaining two clusters contained jobs that either (a) were not well-predicted by the ASVAB subtests or (b) required abilities from across the full spectrum of ASVAB subtests.

Ree and Earles (1992) investigated the validity of the MAGE composites but drew somewhat different conclusions. They computed correlations between final school grades and the ten ASVAB subtests and the MAGE composites. They organized the correlations by job family (e.g., one group of correlations for Mechanical jobs) and computed average corrected-for-range restriction correlations. Some Mechanical jobs were better predicted by the Electronics composite, and Administrative jobs included in the study were generally not well predicted by the Administrative composite. General and Electronics jobs were well predicted by their corresponding composites. Moreover, the Ree and Earles study pointed out some other very specific deficiencies in the MAGE occupational groupings.

Ward, Treat, and Albert (1985) suggested using a hierarchical grouping algorithm developed by Air Force researchers to cluster regression equations to achieve "cleaner" job clusters. To our knowledge, however, this procedure has not been fully applied to ASVAB data.

The Army Cognitive Taxonomy. The Army began using aptitude area (AA) composites along with the Army Classification Battery operationally in 1949 (Maier & Fuchs, 1969). In the five decades since then, the test battery (now the ASVAB), the Army's occupational structure, and the AA composites have changed. The Army has used nine AA composites, resembling those in use today, since 1973. The two latest generations of AA composites were formed by Maier and Grafton (1981) and McLaughlin, Rossmeissl, Wise, Brandt and Wang (1984). Maier and Grafton used an operational measure of job performance, Skill Qualification Test (SQT) scores, as criteria for developing composite formulas; they did not, however, investigate alternative groupings of jobs. Usually, when new jobs have been created, they have been assigned AA composites based on rational judgment.

McLaughlin et al. (1984) examined ASVAB validities corrected for range restriction against SQT and training scores for 98 jobs. Almost all jobs were best predicted by their assigned AA composite. McLaughlin et al. also developed an alternative set of four composites -- Clerical, Skilled and Technical, Operations, and



Combat. However, validity of the four-composite set was not significantly different from that of the nine composite set.

More recently, Johnson, Zeidner, and Leaman (1992) used the McLaughlin et al. (1984) data base to investigate alternative job clustering strategies. They compared estimates of mean predicted performance (MPP) produced for the nine operational AA composites, 16 a priori job families, and 23 Career Management Fields (CMF) represented by 60 jobs. Their data supported Brogden's (1959) finding that increasing the number of job clusters increases classification efficiency.

The Marine Corps Cognitive Taxonomy. The Marine Corps developed the latest version of its composites in 1985. Maier and Truss (1985) computed regression equations for predicting training school grades in 34 job groups. ASVAB factor composites were used in the regression rather than subtests to enhance the stability of the results. The four ASVAB subtest factors were: (1) Verbal (WK and PC), (2) Mathematical (AR and MK), (3) Technical (AS, MC, and EI), and (4) Speed (NO and CS). The mathematical factor had a high weight for all samples, and the authors concluded that all composites should include at least one math subtest. Similarly, the technical factor had high weights for all specialties, except clerical jobs; the speed factor had high weights for clerical and field artillery jobs, and the verbal factor had high weights for general technical and clerical jobs. The authors constructed the composites accordingly.

The occupational clusters associated with the four composites have been defined over the years on an empirical basis, coupled with rational judgment and knowledge about the jobs. Examples of the types of occupations associated with the occupational composites (from Maier & Truss, 1985, p. 4) are:

- Mechanical and Crafts (Motor Maintenance)- automobile mechanic, carpenter, aviation mechanic,
- Business and Clerical (Clerical)- office secretary, bookkeeper, inventory control,
- Electronics and Electrical (Electronics Repair)- TV-radio repair, computer repair, electrical equipment repair,
- Health, Social and Technology (General Technical)- laboratory technician, police officer, computer operator.

The Navy Cognitive Taxonomy. The Navy currently uses 11 ASVAB composites and has, over the last few years, investigated ways of reducing the number of composites. Peterson, Gialluca, Borman, Carter, and Rosse (1990) gathered school performance data on more than 20,000 students attending 22 Navy Class "A" schools. They applied several rational and empirical strategies for ASVAB composite development including: (a) the 11 composites currently used operationally, (b) alternative rational composites suggested by Navy Personnel Research and Development Center (NPRDC) researchers, (c) rationally-derived composites used in other Services, and (d) three strategies for empirically identifying alternative composites. They computed corrected-for-range-restriction

validities associated with each method. The current composites demonstrated good validity, although alternative rational composites were slightly more valid, on average. The empirical strategies produced somewhat higher validities but appeared to capitalize on chance to some extent.

### Interest-Based Descriptions

Probably the most widely-used occupational taxonomy, which is not based on cognitive requisites for jobs, is Holland's vocational interest-based scheme (Holland, 1983). Holland found that most of the scales comprising previously-existing interest inventories could be subsumed under four to eight categories, and that these different interest constructs have relatively stable relationships with one another. He named the primary six interest themes as follows: Realistic, Investigative, Artistic, Social, Enterprising, and Conventional (RIASEC). He also posited that occupations could be described in terms of the RIASEC factors, and research has supported this idea. For example, the job "secretary" is characterized by conventional interests; "Navy officer" is described by realistic interests (Campbell & Hansen, 1981).

In the past, occupational descriptions using Holland's scheme were often derived by asking job incumbents to complete an interest inventory and profiling their responses according to RIASEC. Recently, Gottfredson and Holland (1990, 1991) developed a job analysis instrument framed around Holland's six interest themes, the Position Classification Inventory (PCI). PCI developers integrated research on personality, work behavior, and aptitude correlates of the RIASEC categories and constructed items based on the observed relationships. The resulting instrument (PCI) has 84 items linked to the RIASEC categories. Job analysts or SMEs rate the job or occupation using the scales on the PCI. The result is a profile of the job (or occupation) according to the RIASEC factors.

### Personality-Based Descriptions

Since personality research has begun to converge on the number and content of replicable factors in personality instruments (Barrick & Mount, 1991; Digman, 1990; Tett, Jackson, & Rothstein, 1991), efforts to link job activities to defined personality constructs are now tenable. The so-called "big five" replicable factors are: (1) Extraversion (gregarious, open), (2) Affability (amiable, cooperative), (3) Conscientiousness (trustworthy, persistent), (4) Emotional Stability (well adjusted, calm), and (5) Intellectance (thinking, creative).

Guion and his associates (1992) believed that personality constructs are too often overlooked in job analysis. To address this deficit, they developed a job analysis instrument that could be used to identify systematically aspects of work potentially related to individual differences in personality. They wrote statements about job activities related to the "big five" personality constructs. Example statements include:

Effective performance in this position requires the person to:

- "remain calm in a crisis situation" (directed toward the Emotional Stability construct)
- "enter customers homes when they are not present" (aimed at Conscientiousness)

One hundred psychologists made judgments about the items and their dimensionality. The final job analysis form has 109 items designed to tap 12 personality constructs (subdivisions of the big five). It is still in experimental stages of development.

### Physical and Psychomotor Ability Descriptions

Although they have historically received relatively little attention by psychologists, defining the physical requirements of jobs is important to the establishment of valid and fair selection and classification systems. Physical abilities tests traditionally have adverse impact on women, and it is likely that physical measures will be contested in court unless their job relatedness is well-supported. Also, the degree of adverse impact varies considerably by physical abilities construct and even for specific tests related to constructs. It is therefore important to ensure that the proper constructs are being measured for specific job tasks.

Over the last few decades, Hogan and Fleishman have advanced our understanding of physical job requirements significantly by defining and validating physical abilities constructs. Fleishman's (1975) original taxonomy had nine physical proficiency constructs:

- |                           |                          |
|---------------------------|--------------------------|
| • Static Strength         | • Explosive Strength     |
| • Dynamic Strength        | • Trunk Strength         |
| • Extent Flexibility      | • Dynamic Flexibility    |
| • Gross Body Coordination | • Gross Body Equilibrium |
| • Stamina                 |                          |

Hogan (1991a, 1991b) adapted and revised Fleishman's dimensions to better reflect physiological functioning and work performance. Her categories are seven-fold:

- |                      |                            |
|----------------------|----------------------------|
| • Muscular Tension   | • Muscular Power           |
| • Muscular Endurance | • Cardiovascular Endurance |
| • Flexibility        | • Balance                  |
| • Coordination       |                            |

A job analysis methodology designed specifically to identify and scale physical abilities needed for job or task performance is the Index of Perceived Effort (IPE; Hogan & Fleishman, 1979). IPE is a method of identifying which tasks, within a set of tasks, are particularly critical and physically demanding. Job analysts or SMEs rate job tasks using a

seven-point scale of perceived effort. These ratings correlate highly with the actual metabolic costs of task performance. Mean task ratings can be compared within and across jobs.

Fleishman (1975) also developed a taxonomy of nine abilities that are primarily psychomotor in nature:

- Multilimb Coordination
- Control Precision
- Manual Dexterity
- Arm-Hand Steadiness
- Aiming
- Rate Control
- Speed of Arm Movement
- Finger Dexterity
- Wrist-Finger Speed

A methodology for linking the Fleishman physical and psychomotor abilities to job requirements is described below.

#### Cross-Domain Person-Oriented Descriptions

Some researchers have attempted to merge research findings across individual attribute domains (e.g., cognitive, personality) to provide a more comprehensive set of descriptors related to individual attributes. For example, researchers in the Army's Project A developed a taxonomy of individual attributes based on comprehensive literature reviews of cognitive, psychomotor, and non-cognitive (i.e., interest and temperament) predictor variables (Campbell, 1987). This taxonomy incorporated 53 constructs which were categorized into 21 clusters. The clusters, in turn, were aggregated into eight higher level factors. The eight factors and their constituent clusters are listed in Figure 4. This taxonomy was used as a guide for the development of a broad array of predictors that were used in subsequent stages of the Project A research. Experimental methodologies for linking these person-oriented constructs with job content specifications are described in the next chapter. (See the section on the JSERT project.)

Fleishman and his colleagues (e.g., Fleishman, 1975; Fleishman & Mumford, 1988; Fleishman & Quaintance, 1984) have also developed a broad-based taxonomy of individual attributes. This taxonomy includes cognitive, psychomotor, and physical abilities. The original taxonomy was based primarily on the work of Guilford and Hopfner (1966) for the cognitive abilities and Fleishman et al.'s own empirical work for the physical and psychomotor abilities. Over the years, the taxonomy has been refined and expanded to include additional constructs in these domains. Currently, the taxonomy incorporates the 50 constructs listed in Figure 5 (Fleishman & Mumford, 1988).

Fleishman et al. have developed a systematic approach for identifying the individual attribute requirements for particular jobs using the Manual for Abilities Requirements Scales (MARS). The latest version of MARS incorporates behaviorally anchored rating scales for each of the 50 abilities shown in Figure 5. Job analysts or SMEs rate job tasks on the Ability Requirements Scales (e.g., the extent to which Task X involves Ability Y). This results in an ability profile for each task. Profiles can be compared across tasks in one job or across jobs.

Factors	Clusters
Cognitive Abilities	Verbal Ability/General Intelligence Reasoning Number Ability Perceptual Speed and Accuracy Investigative Interests Memory Closure
Visualization/Spatial	Visualization/Spatial
Information Processing	Mental Information Processing
Mechanical	Mechanical Comprehension Realistic vs. Artistic Interests
Psychomotor	Steadiness/Precision Coordination Dexterity
Social Skills	Sociability Enterprising Interests
Vigor	Athletic Abilities/Energy Dominance/Self-esteem
Motivation/Stability	Traditional Values/Conventionality/ Non-delinquency Work Orientation/Locus of Control Cooperation/Emotional Stability

**Figure 4. Project A Individual Attributes Taxonomy**

Oral Comprehension	Selective Attention
Written Comprehension	Time Sharing
Oral Expression	
Written Expression	Static Strength
Fluency of Ideas	Explosive Strength
Originality	Dynamic Strength
Memorization	Trunk Strength
Problem Sensitivity	Extent Flexibility
Mathematical Reasoning	Dynamic Flexibility
Number Facility	Gross Body Coordination
Deductive Reasoning	Gross Body Equilibrium
Inductive Reasoning	Stamina
Information Ordering	Near Vision
Category Flexibility	Far Vision
	Visual Color Discrimination
Spatial Orientation	Night Vision
Visualization	Peripheral Vision
	Depth Perception
Perceptual Speed	Glare Sensitivity
Control Precision	
Multilimb Coordination	General Hearing
Response Orientation	Auditory Attention
Rate Control	Sound Localization
Reaction Time	
Arm-Hand Steadiness	
Manual Dexterity	
Finger Dexterity	
Wrist-Finger Speed	
Speed of Limb Movement	

**Figure 5. Ability Categories in Updated Manual for the Ability Requirement Scales**

#### **IV: Situation-by-Person Taxonomy Linkages**

Several research efforts have ventured beyond the job-specific work-by-person linkages to provide a more global understanding of the linkages between situation-based constructs and person-based constructs. Some of these projects are summarized here. These efforts are critical to our review since military job analysis strategies which are intended to support personnel classification goals cannot be predicated on the notion that job performance can be empirically linked to a given set of predictors for every job.

To the extent that the linkages between situation-based constructs and person-based constructs are made through expert judgment rather than empirical data, several issues become important in evaluating the research. These include (a) Who are the experts who can make these judgments reliably (e.g., incumbents, psychologists)?, (b) What kind of information do judges require?, and (c) What kinds of rating scales work best? Keep in mind that this review is not intended to be exhaustive. Rather, we are focusing on efforts that are the most applicable to the Services' specific needs.

##### **PAQ Attribute Profiles**

Developers of the PAQ had a group of industrial psychologists estimate the relevance of 68 individual attributes for each of rated PAQ job elements using a five-point scale (McCormick, Jeanneret, & Mecham, 1972). Each of the 29 raters judged the relationship between a subset of the situation element (PAQ job element) by person element (individual attribute) pairs to result in a complete matrix of estimates regarding the relevance of each person element to each situation element. Each cell entry was based on input from at least eight raters, and inter-rater reliability for these judgments was reasonably high.

An empirical synthetic validity (Lawshe, 1952) type of linkage was also incorporated into the PAQ system (McCormick & Jeanneret, 1988). Based on the empirical relationship between PAQ data and successful incumbent performance on the General Aptitude Test Battery (GATB) for 163 jobs, GATB subtest score requirements can be estimated for jobs not part of the original sample. So that this information can be generalized to private organizations that do not have access to GATB, GATB subtests were matched to some commercial tests in an additional study conducted on incumbents in 202 jobs. Another empirical strategy has been to use the PAQ as a foundation for clustering jobs for purposes of validity generalization. This strategy has been used successfully in the insurance industry (Colbert & Taylor, 1978). Specifically, jobs clustered using the PAQ showed greater validity generalization within clusters than across clusters. Thus, jobs could theoretically be clustered using this method such that all jobs within a cluster would use the same selection and classification tests and these tests would differ across job clusters.

Thus, both empirically-based and judgment-based methods have been used to link PAQ situation elements with various person-based elements. Either strategy could be used in the future to make similar linkages using person-based elements of primary interest to the

military (e.g., ASVAB and its supplements). Sackett (1991) has also discussed the possibility of applying this type of methodology to job analysis in the military.

### Army Synthetic Validity Project

In the Army's Project A, the relationship between a broad range of predictors and criterion measures was examined for a sample of 19 MOS. The Synthetic Validity project (SYNVAL) was conducted to investigate methods for using the synthetic validity model to apply empirical information generated in Project A to the entire spectrum of Army MOS. The researchers captured the scope of their work best with the following summary:

The Synthetic Validity Project developed and evaluated a series of alternative procedures for: (a) analyzing jobs in terms of their critical components, (b) obtaining expert judgments of the validities of an array of individual attributes for predicting the critical components of performance, (c) establishing prediction equations for specific jobs when criterion-related validation is not available, (d) estimating criterion referenced performance standards for specific jobs, and (e) specifying scores on the predictor battery that would be necessary to achieve the desired performance standard, given the bivariate distribution between predictor scores and performance scores (Wise, Arabian, Chia, & Szenas, 1989, p. 7-1).

Two situation-oriented job component taxonomies were developed by the SYNVAL researchers, essentially corresponding to the job-oriented and worker-oriented descriptions outlined above. The Task Category model was based on a review of general job descriptions for a sample of 111 entry-level MOS and the results of empirical validation work. The taxonomy includes 96 elements (i.e., task categories) grouped into five types of clusters: (1) maintenance, (2), general operations, (3) administrative, (4) combat, and (5) supervision. A sample element from this taxonomy is shown below:

**Operate Gas and Electric Powered Equipment:** Operate electric generators, air compressors, smoke generators, quarry machines, mobile washing machines, water pumps, etc. to produce power or process materials.

The Job Activity model was based on a review of existing instruments, including the PAQ, OAI, and Functional Job Analysis scales, and a review of the literature on behavioral taxonomies. The activity taxonomy includes 53 elements grouped into seven types of clusters: (1) interpersonal behaviors, (2) speaking behaviors, (3), writing behaviors, (4) cognitive behaviors, (5) complex problem solving, (6) operating equipment, and (7) physical activities. A sample element from this taxonomy is as follows:

**Operate hand-held power equipment:** Operate hand-held power assisted equipment (for example, electric saw, electric wrench, etc.).



The person-based taxonomy used in the SYNVAL research was drawn primarily from the Project A research (see Figure 4). This taxonomy includes 31 attributes covering four domains (1) cognitive, (2) coordination and physical, (3) temperament/ attitude, and (4) interests (Hoffman, 1991).

Based on preliminary research findings, the Task Category model was selected as the best strategy for portraying the situation-oriented side of the job analysis model. A total of 69 expert judges (psychologists) estimated the correlations between individual attributes and task categories. NCOs and officers rated the relevance of task categories for 21 MOS with respect to three dimensions of performance (core technical, general soldiering, and overall job performance).

Results of this aspect of the SYNVAL project indicated that SMEs (psychologists and Army personnel) were able to make highly reliable judgments, and that the synthetic prediction equations resulting from their input closely corresponded with the results of empirical research (i.e., Project A). Discriminant validity was highest for the empirically-derived equations, although some ways of deriving the synthetic equations came close to matching the empirical equation results. The disappointing finding, however, was that discriminant validity was relatively low for both empirical and synthetic equations.

#### Methods for Identifying Abilities in Air Force Specialties (MIDAS)

The Air Force initiated the MIDAS project to investigate ways of linking components of work with ability requirements. The project began with the identification of an ability taxonomy to use in the research (Driskill, Weissmuller, Hageman, & Barrett, 1989). They chose to adapt Fleishman's Ability Requirements Scales (ARS) for their needs (Fleishman & Quaintance, 1984). One of the modifications to the ARS system was to expand it to cover a broader range of attributes including sensory, perceptual, cognitive, psychomotor, communication, and interpersonal abilities. The final ability list contained 28 elements. Two strategies were used to define the situation domain. One strategy was to use task action verbs from the Air Force occupational analysis inventories to categorize tasks across jobs (e.g., all tasks beginning with "repair" were grouped together). In essence, the task action verbs became the situation-based taxonomy. The other strategy used the relevant elements from the GWI described in Chapter 2. The plan was to use SMEs (supervisors) to provide expert judgments regarding the link between the ability taxonomy and each of the two situation taxonomies.

A test of this methodology was recently conducted in which the situation-person linkage was attempted for four officer and four enlisted Air Force jobs (J. Earles, personal communication, June 4, 1992). Task action verbs across these jobs yielded 80 task categories. A judgment package was constructed which included (1) a description of the abilities in ARS format, (2) a booklet for rating the importance of the 28 abilities for each task category (with description of the relevant action verb and sample tasks), and (3) a booklet for rating the importance of the 28 abilities for each GWI element. An 11-point scale

was used to estimate importance. For example, ratings at the middle of the scale corresponded to the phrases:

Average Importance: About 50 percent of the actions needed to perform the task can be correctly completed with an average level of this ability.

Slightly Below Average Importance: About 60 percent of the actions needed to perform the task can be correctly completed with an average level of this ability.

"Average level of ability" refers to the average level found in a typical high school graduate.

One hundred SMEs were asked to complete the rating package, and thirty completed packages were returned. Despite the fact that interrater reliabilities of the importance ratings were high (J. Earles, personal communication, June 4, 1992), it seems reasonable to speculate that the low response rate was partially due to the complexity of the rating scale anchors and associated rating activity. In any case, factor analysis of the task-based importance ratings yielded four underlying ability requirements -- verbal, quantitative, psychomotor, and spatial. Factor analysis of the GWI-based importance ratings yielded a similar factor structure but without the spatial component.

#### Job Sets for Efficiency in Recruiting and Training (JSERT)

Unlike the other Services, the Army normally guarantees each new recruit a specific MOS upon enlistment. Rapid changes to enlisted end strength and specific MOS training seat authorizations, however, make it difficult to match enlistments to MOS enlisted strength goals at any given time. Guaranteeing recruits a set of MOS rather than a specific MOS would give the Army the flexibility to match MOS enlistment goals more closely. Furthermore, classification into specific MOS could take place after initial training and therefore be based on more predictive information (e.g., performance in training as well as ASVAB scores). Finally, MOS sets could also be used to make training programs operate more efficiently. The Job Sets for Efficiency in Recruiting and Training (JSERT) project was designed to devise ways for setting up a system for clustering MOS into job sets and computing prediction equations for MOS within those sets (Arabian & Schwartz, 1990). The two different approaches that were examined are described briefly below. Both of these approaches have been pilot tested and show some promise for future applications.

One approach in the JSERT project was to design software to use data from the Army Task Questionnaire developed in the SYNVAL project to cluster jobs and compute synthetic equations for performance prediction (Whetzel, Rosse, & Peterson, 1992). Specifically, the "MOS Analysis System" (a) performs quality checks on the questionnaire data, (b) computes descriptive statistics and interrater reliability estimates, (c) adds data from additional MOS to the existing master database (initially constructed in the SYNVAL project), (d) clusters MOS based on two measures of similarity (correlation and d-square statistics), and (e) synthetically derives predictor weights for ASVAB and the Project A predictor tests.

The second approach used in the JSERT project was the "Job Requirements System," a clustering strategy in which jobs are grouped on the basis of a taxonomy of 14 types of worker-oriented activities measured by the Job Requirements Index (Rossmeisl, Schendel, & Jordan, 1991). This taxonomy was adapted from Berliner, Angell, & Shearer (1964) and McCormick (1979). Activity categories are rated on relative time spent and relative importance. These ratings can be used to group jobs based on profile similarity. In order to take advantage of empirical results from Project A, hands-on performance measures for nine MOS studied in that research were categorized into the activity categories. Using the validity estimates between the activity categories (operationalized with the relevant hands-on test data) and the predictor tests (ASVAB and several of the Project A experimental tests), a look-up table indicating the magnitude of the relationship between each of the activity categories and the predictors was constructed. A second table was constructed which lists the Project A tests which measure each predictor construct and, for each test, reports its uniqueness compared to ASVAB, its reliability, and the time it requires for administration. Using the Job Requirements Index as a starting point, then, this system provides a series of decision rules to identify predictor tests to use for classifying enlisted personnel.

### OPM Research

OPM has recently conducted several studies designed to evaluate the utility of holistic approaches to the problem of linking ability requirements to job requirements (Rheinstein, O'Leary, & McCauley, 1990). In this research, seven abilities measurable in a written format and identified through a literature review were used. They were:

- |                        |                       |
|------------------------|-----------------------|
| • Verbal Comprehension | • General Reasoning   |
| • Number Facility      | • Logical Reasoning   |
| • Perceptual Speed     | • Spatial Orientation |
| • Visualization        |                       |

In one study, five psychologists rated the importance of each ability (using a five-point scale) for each job. Their judgments were based on a review of a list of major duties for each job. Job family ability requirements were obtained by averaging the judged ability requirements for the constituent jobs. Approximately 6,000 job incumbents were asked to make the same type of holistic judgments for each of the seven abilities with regard to their own job. Judgments made by each of the two groups (psychologists and incumbents) were reliable and the two groups agreed on the relative importance of the abilities for the various job families. Although the differences were not in any consistent direction, the two groups of judges produced ratings that showed differences in magnitude. The holistic judgments made by job incumbents were also compared to judgments they had made based on individual duty areas. In this comparison as well, both sets of incumbent judgments were reliable and the two sets corresponded with each other with respect to the relative importance of the abilities, yet there were absolute differences between the judgments.

## DoD Linkage Project

The purpose of Phase I of the DoD Linkage project was to determine the statistical relationship between job performance and individual characteristics across jobs and across Services (Harris et al., 1991). In a second phase of the project, researchers are constructing a cost/performance tradeoff model. Data for this project come from the Job Performance Measurement (JPM) projects conducted by each of the individual Services. JPM projects were initiated by each of the Services in the early 1980's in response to a Congressional mandate calling for an explicit linkage between military enlistment standards and job performance.

Since the goal of Phase I was to predict job performance, work information (e.g., cognitive complexity) and person characteristics (e.g., aptitudes measured by the ASVAB) were not crossed with each other as depicted in our job analysis model shown in Figure 1. Rather, they were incorporated as predictors of performance in a set of multilevel regression equations. As discussed by Guion (1976), situational information can be potentially used as a predictor or moderator in personnel selection research to the extent that it impacts the predictability of criterion performance. It is in this manner that situational variables have been used in the Linkage project research.

## Commentary

Several examples of research efforts to link individual attributes with job requirements have been described in this chapter. Each uses its own mix of empirical and judgmental data, as well as synthetic validity and validity generalization research strategies. None addresses all of the classification goals voiced by the Services, but each attempts to address one or more of the goals in one way or another. Thus, as we look at this body of research, no strategy jumps out as the "best." Indeed, at this stage it even seems premature to identify any of the research efforts as redundant. For example, MIDAS and SYNVAL are looking at very different approaches to linking work components and predictors. As we learn more from these types of projects, however, it will soon be the case that the Services should try to converge on the most promising approach(es) that can be developed for use by all Services for job clustering purposes (whether for personnel classification, training, or other administrative needs). It is our belief that there is much to be gained by cooperative research and operational activities. Such collaboration is made more feasible by the fact that most of the approaches that have been experimented with could be adapted for use by all of the Services, even if their original incarnation has been Service-specific or civilian.

With respect to categorizing jobs for selection and classification, the strategy pursued over the long run should result in a relatively large number of clusters that maximize homogeneity within clusters and heterogeneity across clusters (Johnson et al., 1992). On the one hand, elements in the taxonomy need to be as job specific as possible to maximize differential validity but on the other hand, the elements need to be general enough to apply across jobs. Perhaps research efforts will be aided by elaborating more on some elements than others. This might translate into a rather lopsided taxonomy in which general job

requirements (e.g., maintaining physical fitness) are lumped together, whereas more job-specific technical requirements (e.g., repairing vehicles) are broken down into more specific dimensions. Whatever job analysis strategy is used, however, it is clear that the strategy that is adopted will significantly influence how much of the true

discriminant validity that exists in the job structure can be used by the selection and classification assignment system.

## **V: Review and Commentary**

The Services have made great strides in collecting information that fills out the situation-based descriptions of the job analysis model on a relatively molecular, job-specific level (i.e., the TI-CODAP occupational analysis programs). They have also been supporting several research projects aimed at deriving a broader based, force-wide taxonomy (e.g., SYNVAL, GWI, MIDAS). The MIDAS work experiments with a classification system that can be drawn directly from available occupational analysis information (i.e., task action verbs). The other efforts require collection of data on a research instrument (e.g., the Army Task Questionnaire or the GWI). Finally, all of the Services also have ways of clustering jobs based on ASVAB prediction equations. These observations bring to mind several issues worthy of consideration which are described briefly below.

### Coordination of Goals and Activities

First, there are multiple goals in the Services that are or could be addressed with job analysis information. These goals vary across organizational function (e.g., training vs. classification) and across organizations (e.g., Army vs. Air Force). It may be the case that different job analysis strategies (e.g., job classification schemes) are necessary to adequately support different needs. The researcher's desire for greater scientific advances and the reality of increasing resource constraints argue, however, for a more systematic effort to review job analysis goals within and across Services to identify similarities and superficial differences that would allow for more cooperative efforts to be instituted and to identify those more fundamental differences which necessitate relatively independent efforts.

Such a review effort would require increased communication and cooperation within and across Services. Vehicles for this exchange are becoming increasingly apparent. For example, the Army moved its occupational analysis program from the Training Command to PERSCOM to expand the job analysis program's perspective on Army needs. However, there is still relatively little communication between PERSCOM and the Army Research Institute which is responsible for R&D associated with selection and classification, as well as training. The International Committee of Occupational Analysis Leadership has been organized to facilitate communication across operational occupational analysis programs. An example at a very broad level is the Training and Personnel Science, Technology, Evaluation, and Management (TAPSTEM) group which includes representatives from all of the U.S. Armed Services. The success of these types of committees is unclear at the present time, but their potential for helping with a broad-based needs assessment is significant.

Improved coordination across those who conduct job analyses and those who do use, or could use, the data could result in a number of outcomes. As discussed in Chapter 3, there

is real potential for at least limited consolidation of operational task analysis efforts across Services. At the job classification level, the potential for cooperation and consolidation appears even more significant. Given that job classification strategies are by nature non-job-specific, it should be feasible to produce strategies that are not Service-specific. In fact, the biggest stumbling block is likely to be different management philosophies espoused by the Services (e.g., whether a situation taxonomy should include "fuzzy" work requirements such as helping co-workers). Despite such difficulties, it seems highly probable that many efficiencies of research effort could be achieved with common worker-oriented and person-oriented taxonomies across the Services.

### Job Clustering Taxonomies

For purposes of personnel selection and classification, all the Services currently cluster jobs based on empirical research linking ASVAB to training performance. This methodology cannot be applied, however, when the selection and classification system is changing to incorporate new predictors that have been validated against job performance, but only for a subset of military jobs. That is why the Services need to examine different strategies for making selection and classification test decisions for each job and for clustering jobs for this and related purposes. In the future, jobs may be clustered by the estimated (e.g., via synthetic validity) validity of certain predictors for predicting performance. Alternatively, the clusters may be based on a situation-oriented or person-oriented taxonomic structure. Sackett (1991) appears to advocate the use of ability descriptors or overall nature descriptors to cluster jobs for personnel classification. To the extent that they are based on specific measures, however, attribute-based job clusters would have to change every time the array of possible selection and classification tests was modified.

Theoretically, a job analysis system could incorporate a sliding scale of descriptive analysis in which specific tasks could be categorized into general behaviors which could, in turn, be categorized into associated individual attribute requirements. Each level simply represents a higher order aggregation of job requirements and of jobs themselves. The potential usefulness of such an integrated system would be boundless since the information collected could support multiple job clustering strategies and other organizational needs. Constructing such a system would be possible if it were true that tasks require certain behaviors which require certain attributes, and conversely, that people with certain attributes can exhibit certain behaviors which are required for certain tasks. We believe that these statements are true and that the construct validity of a job analysis system can be tested using these assumptions. Whatever strategy is taken, however, the issue of what is the "right" descriptor to use for selection and classification research is a complex one that will not be resolved here. Rather, we simply wish to point out that the answer is not obvious, and deserves considerable consideration.

A related issue is the level of taxonomic specificity required for defining jobs for various organizational needs. To satisfy personnel classification needs, the organization must be able to cluster jobs. Job descriptors such as those used in the TI-CODAP occupational analysis programs (i.e., highly specific job tasks) will not support this need unless they can be

grouped into higher level categories that are common across jobs. We have described several efforts to accomplish this type of task categorization, but the ultimate success of these attempts is not yet clear. Even descriptor taxonomies which are applicable across jobs, however, can still vary considerably with regard to specificity. The level of descriptive specificity that is appropriate for best reflecting the true latent structure of job requirements is a research question of considerable interest. That is, research needs to address the question of how much taxonomic specificity is necessary and how much is too much. Too much detail in the taxonomic system (at any given hierarchical level) will bog down the personnel systems that rely on it, making those systems inefficient and unwieldy. Too little detail will result in substandard personnel systems because they will ignore important job information.

### Potential New Directions

This review of job analysis studies is also intended to identify areas that have been neglected. We have already mentioned the relative lack of attention to the National Guard and Reserve forces. Although these are clearly difficult jobs to study (as are highly classified jobs in the active forces), they are critical to overall organizational performance, and job analysis taxonomy models need to be constructed so that these types of jobs can be accommodated.

With few exceptions, the Services have used task-based or worker-oriented surveys to collect job analysis information. Other strategies such as critical incident methodologies, however, might be a source of valuable supplemental information that would round out the description of both situation-oriented and person-oriented job requirements. For example, critical incidents tend to identify interpersonal and communication job requirements that can go unnoticed in a task-based job description. They can also potentially identify motivational, physical, and other requirements for jobs. Additionally, critical incident information can be invaluable for the development of predictor and criterion measures. Instruments such as rating scales, situational judgment tests, and assessment center-type exercises all typically rely on critical incident information.

Campion (1992) has advocated job analysis innovations that explicitly assess job design characteristics. He identified four job design models: (1) mechanistic, (2) motivational, (3) perceptual-motor, and (4) biological. Each model views jobs from a perspective that may not be captured by traditional job analysis methodologies. The information gained by information regarding job design characteristics, such as degree of task interdependency, autonomy, environmental stressors, and work pace, may be related to individual differences in job performance and therefore be useful for identifying selection and classification tests. Furthermore, this information would be useful for job redesign efforts which are a major concern for the Services in this era of downsizing. Campion and his associates have developed several experimental job analysis instruments which assess job design characteristics from the perspective of each of the above models as well as a measure of task interdependency. Their self-report items could be appended to traditional job analysis instruments (e.g., task inventories or standardized worker-oriented surveys) to further explicate situation-oriented job requirements.



The classification objectives listed in Chapter 1 call for job analysis information related to (1) the nature of individual contributions to unit performance and (2) highly cognitive job requirements. Although these are not conflicting interests, they are opposing in the sense that defining unit (or team) performance requirements reaches beyond individual task requirements and defining cognitive task requirements delves more deeply into individual task requirements. Both types of research are in their infancy, particularly as applied to the area of selection and classification research. As a result, there is little literature to incorporate into our review.

Individual contributions to team/unit performance. Because a large proportion of Service personnel work in teams and because this trend is expected to grow, interest in addressing team performance requirements is also increasing. One potential impediment to progress in this area is a failure to distinguish clearly the concepts of "individual performance," "team performance" and "an individual's contribution to team performance." In selection and classification research, it is reasonable to try to identify individual differences (e.g., cooperativeness) that predict individual contributions to team performance (e.g., willingness to help peers), but measures of team performance should not be used as criteria against which to validate individual selection and classification measures. Such an effort would mix levels of analysis, and hence be uninterpretable from the start. Distinguishing between team performance requirements and individual job requirements that are necessary for team performance is a difficult, but we believe attainable, goal. For example, researchers might start with Dieterly's (1988) model of job analysis for teams. He suggests ways in which standard TI-CODAP procedures can be expanded to yield information about individual activities that are related to team performance. Another strategy would be to use critical incident methodology which might be more likely to result in the identification of individual attributes and process variables which impact team performance.

A more thorough understanding of how individuals interact with teams to accomplish goals could be used in a variety of ways. For example, the structure imposed on teams could be changed to maximize performance efficiency. This might mean reallocating tasks among team members or allowing team members more discretion in allocating tasks among themselves. In terms of selecting individuals for their ability to work as part of a team, sophisticated matching of personalities will probably only be rarely feasible in the first place (e.g., with relatively long-standing special operations teams). Identification of individuals with more general "team player" characteristics (e.g., cooperativeness, leadership skills), however, may pay off for wider application. Thus, increased attention to the interaction of performance requirements across individuals could benefit the military in significant ways. The R&D costs, however, can be expected to be significant as well since this is an under-researched area.

Cognitive Task Analysis (CTA). As mentioned previously, CTA is used to examine in detail the way in which job experts perform one or more cognitively complex tasks. It is an emerging approach to job analysis that has been used primarily to support training systems. Because the examination is so intense, hence time consuming and expensive, it generally should be reserved for a limited number of critical tasks for which it is difficult to select or

train individuals. A prime example of a job for which such tasks exist, and for which CTA has been used, is that of air traffic controller (Means et al., 1988). In one study, three expert controllers were selected for participation in the task analysis. They were videotaped performing three standardized air traffic control exercises on a simulator. Performance measures were developed and interview questions were adopted which examined the ways in which these experts reduced the cognitive demands of the air traffic problem.

Glaser, Lesgold, and Gott (1991) have used cognitive task analysis strategies to study some cognitively complex Air Force tasks (e.g., electronics troubleshooting). They have worked on several strategies to identify differences in how novices and experts perform cognitively demanding tasks, and have used this information to develop performance tests that more adequately capture depth of skill. They warn, however, that these analysis techniques are costly in terms of time and the need for highly skilled personnel.

Although cognitive analyses were originally designed to delineate cognitive processes and aid in the development of expert systems, the type of information these methods yield is potentially useful for a variety of other purposes. It can be used to reorient training programs to address specific segments of a task that are problematic for novices. With regard to the development of predictor and/or criterion measures, cognitive processing information can be used to build realistic task simulations and to develop protocols for scoring task performance. Even so, most of these methods are new, unvalidated, and labor intensive. Further research is needed before they will be broadly applicable job analysis tools.

### Revised Classification Objectives

Finally, we close this report by suggesting several revisions to the list of classification objectives. The job analysis-related objectives listed at the beginning of the report are repeated below. A suggested revision to the second objective is indicated in italics.

- Investigate job clustering methods to improve potential for classification among appropriate job clusters rather than among individual jobs.
- *Identify jobs for which greater understanding of cognitive demands is required for classification purposes, and investigate job analysis methods that more adequately capture nonobservable job requirements for high level performance (e.g., cognitive task analysis).*
- Design and evaluate job analysis methods that yield task to KSA linkages, within defined task and KSA taxonomies, so that worker attribute requirements for jobs are readily and systematically defined.
- Design and evaluate job analysis methods that identify the major contributions of individual performance to unit performance.

- Improve classification efficiency by improving strategies to generalize classification research findings across jobs and military populations.

Objectives we recommend adding to the list are as follows:

- Examine methods for identifying non-cognitive job requirements (e.g., temperament, physical abilities).
- Investigate job analysis strategies that can (a) adapt to rapidly changing technology and force structure and (b) integrate information from different perspectives (e.g., task, behavioral, Service-specific).
- Identify strategies for collecting job analysis data quickly enough to support short-fuse policy decisions (e.g., force structure changes)
- Investigate ways of collecting job analysis data that will help set enlistment/classification standards.
- Examine strategies for using job analysis data to improve personnel reclassification decisions (e.g., changing jobs at reenlistment or selecting Reserve job).

It should be noted that these additional objectives arose primarily from interviews we conducted in the information-gathering part of our effort to write this report rather than from our efforts to synthesize that information. The interviews were with individuals working in the operational occupational analysis programs conducted by each of the Services.

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